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Supplemental Report 7

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GEMINI AGENA TARGET VEHICLE 5004 SYSTEMS TEST EVALUATION (U)

(45-DAY REPORT)

CONTRACT AF 04(695)-545

Issued as Supplemental Report 7
to: Gemini Program Mission Report
Gemini IX-A
MSC-G-R-66-6
by: Gemini IX-A Mission Evaluation Team
National Aeronautics and Space Administration
Manned Spacecraft Center
Houston, Texas

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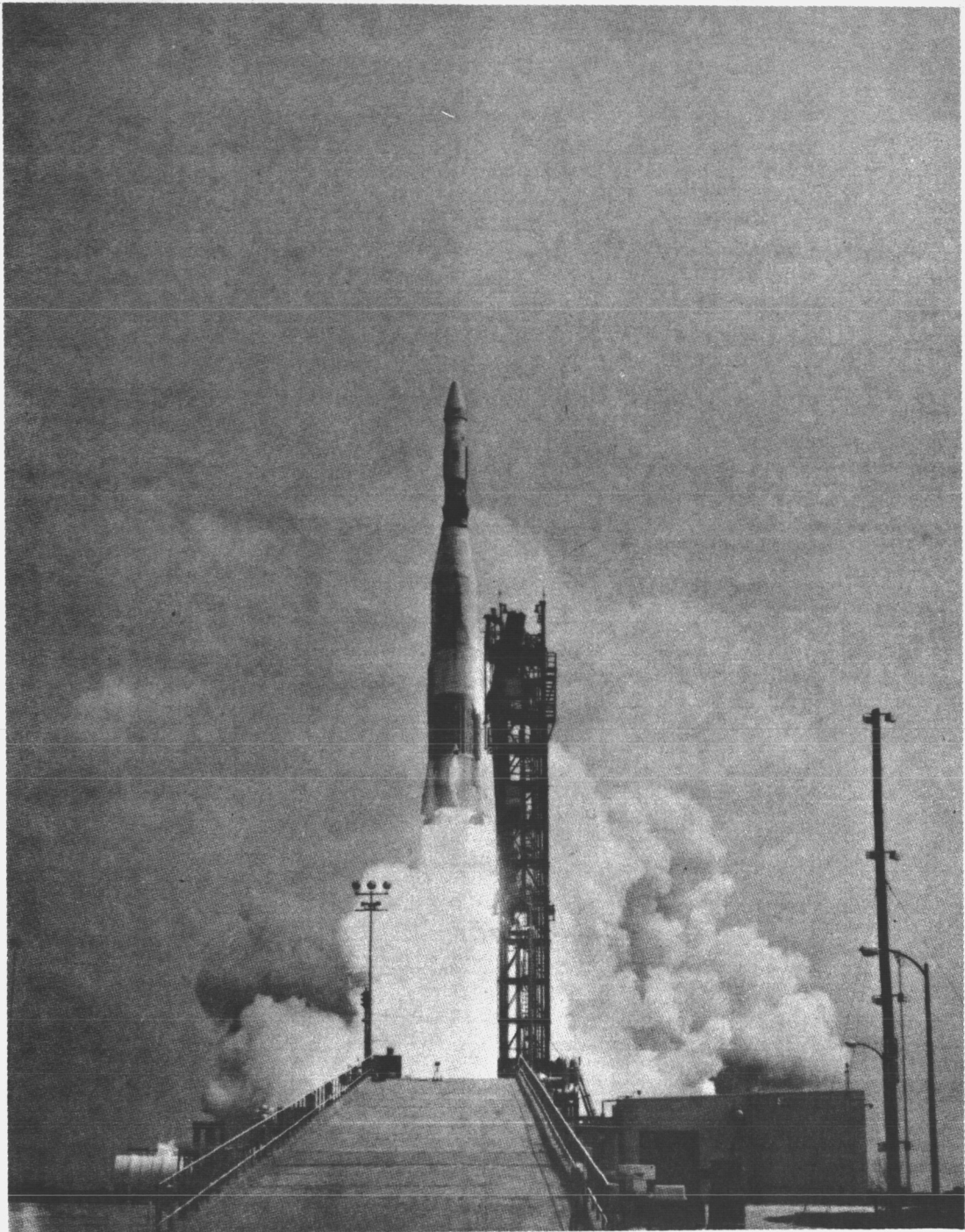
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Atlas/Gemini Agena Target Vehicle 5004

iii

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FOREWORD

This report, prepared by Lockheed Missiles & Space Company in compliance with Contract AF 04(695)-545, documents the flight performance evaluation of Gemini Agena Target Vehicle 5004 launched from the Air Force Eastern Test Range on 17 May 1966.

Pertinent evaluations for the performance of the Atlas Vehicle are based on information transmitted to Lockheed by General Dynamics/Convair (GD/C).

v

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SUMMARY

The countdown for Gemini Agena Target Vehicle (GATV) Serial No. 5004 was initiated at Complex 14, Cape Kennedy, Florida, 17 May 1966 at 0000 EST or 600 min before planned Atlas/GATV liftoff. No vehicle anomalies were experienced during countdown. A hold of approximately 15 min was caused by a facilities problem during IRFNA loading. Weather conditions and surface winds were satisfactory for launch. Liftoff (2-in. motion) occurred at 1515:03.422 GMT (1015:03.422 EST).

The ascent was nominal up to 120.68 sec when an engine, Booster No. 2 (B-2), in the Atlas went hard over causing the Atlas/GATV combination to pitch-tumble at rates estimated to be in excess of 15 deg/sec. As the vehicle pitched, GE guidance was lost and the Atlas boosters were staged by backup accelerometers. At this time the vehicle was pointing almost straight down along the radius vector. After staging, the vehicle regained attitude control but had lost its pitch reference and performed the sustainer phase of the flight pointing approximately counter to its velocity vector. SECO occurred early as a result of fuel depletion; VECO and Agena separation were initiated by backup commands on the Atlas programmer. The Agena continued to transmit telemetry data until about 456 sec. Just prior to this time all exposed temperature monitors showed a very sharp rise in temperature, thereby indicating reentry of the GATV into the earth's atmosphere.

Structural integrity of the Atlas/GATV was maintained during the pitchover and subsequent flight even though the calculated loads on the vehicle approached the ultimate vehicle capability early in the maneuver.

Just prior to BECO, vibrations of an undetermined magnitude and frequency were observed in the two accelerometers mounted in the aft section of the Agena. About the same time, an excessive electrical load was placed on the Type XII-A

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3-phase inverter. This load subsequently caused the inverter to partially fail at 179.49 sec. The inverter supplies 3-phase power to the Agena sequence timer, which stopped on loss of power and did not issue any commands after the Agena separated from the booster.

The most probable cause of the excess load on the inverter was arcing at the J-100 umbilical caused by the Atlas/GATV flying backwards through the ionized exhaust gases from the Atlas engines.

A summary of significant events during this flight is presented in Table S-1.

Table S-1
SUMMARY OF SIGNIFICANT EVENTS, ATLAS/GATV 5004

<u>Events</u>	<u>Flight Time (sec)</u>	
	<u>Nominal</u>	<u>Actual</u>
Liftoff (1515:03.422 GMT)	0	0
Booster engine No. 2 went hard over (mechanical stop), vehicle started pitch down	—	120.68 ^(a)
Booster engine No. 1 limited by hydraulic stop, ground guidance intermittent	—	121.0 ^(a)
Vehicle pitch rate reached instrumentation limit (-3.5 deg/sec)	—	125.0
Momentary telemetry dropout, GE guidance lost track and lock	—	130.08
Booster engine cutoff (BECO), GE guidance (not received)	130.5	—
Main bus current erratic from nominal 13.4 amp	—	130.6
BECO (backup) at 6.6 g from acceleration decay	—	130.977 ^(a)
Main bus voltage drops to 28.17 vdc	—	131.244 ^(b)
Main bus current stabilized at 22.4 amp (9.0 amp over nominal)	—	131.247 ^(b)
Main bus voltage drops to 27.97 vdc	—	131.306 ^(b)
115-vac phase BC drops to 97.5 vac	—	131.498 ^(b)
Booster engine separation, vehicle rolling right	—	134.10 ^(a)
Vehicle pitched over approximately 210 deg from initiation of pitch down	—	136.0
GATV telemetry reacquired, main bus current level at 24.0 amp	—	136.58
GATV rolling left and pitching up	—	138.00
115-vac phase BC drops to 94.9 vac	—	142.498 ^(b)
115-vac phase AB drops to 113.5 vac, 115-vac phase BC drops to 93.2 vac	—	149.5

(a) From GD/C data.

(b) Times listed with six significant figures were read from bit stream. Houston times are rounded off to indicate relative accuracy.

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Table S-1 (Cont.)

<u>Events</u>	<u>Flight Time (sec)</u>	
	<u>Nominal</u>	<u>Actual</u>
Type XII-A inverter temperature starts rapid rise from 72.9° F	-	150.0
Main bus current rises to approximately 27 amp	-	152.8
GATV controlled to a steady attitude	-	154.00
115-vac phase BC has gradually dropped to 90.8 vac, 115-vac phase AB drops to 112.9 vac	-	165.5
115-vac phase AB increases to 116.4 vac, 115-vac phase BC drops to 60.6 vac	-	176.5
Phase BC drops to 0.0 vac	-	177.5
Spin motor rotation direction detector signal lost	-	179.4
Phase AB drops to 91.4 vac then remains at this level	-	182.5
Sustainer engine cutoff (SECO) by LOX depletion at 2.86 g	-	274.28 ^(a)
SECO by GE guidance (not received)	280.0	-
Vernier engine cutoff (VECO) by GE guidance (not received)	298.4	-
VECO by backup (Atlas programmer)	-	299.36 ^(a)
H/S fairings ejected, gyros uncaged	-	299.36
Inverter temperature up to 117° F	-	299.36
Atlas/GATV separation initiated	301.0	301.68 ^(a)
GATV free of adapter	-	303.88
GATV tumbles at 5 rpm after separation	-	303.8
GATV roll rate at 5 rpm, increasing to 15 rpm at LOS	-	304 to 440
Data lost (vehicle clock stopped)	-	456.6

(a) From GD/C report.

x

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CONTENTS

Section	Page
FRONTISPIECE	iii
FORWARD	v
SUMMARY	vii
ILLUSTRATIONS	xiii
TABLES	xiv
ABBREVIATIONS	xv
1 INTRODUCTION	1-1
1.1 Purpose and Scope	1-1
1.2 GATV Objectives	1-1
1.3 Countdown	1-2
2 FLIGHT PROFILE	2-1
2.1 Radar Tracking	2-1
2.2 Weight Data, GATV 5004	2-5
3 GATV SUBSYSTEM EVALUATION	3-1
3.1 Structures	3-1
3.1.1 Launch Wind Environment	3-1
3.1.2 Structural Loads	3-1
3.1.3 Structural Dynamics	3-2
3.1.4 Separation Dynamics	3-7
3.1.5 Thermodynamics	3-7
3.2 Secondary Propulsion System	3-13
3.3 Primary Propulsion System	3-13
3.4 Electrical Power System	3-13
3.5 Guidance and Control	3-18
3.5.1 Event Monitors	3-19
3.5.2 Vehicle Motion/Control Performance	3-19

Section	Page
3.5.3 Temperature Monitors	3-22
3.5.4 Pressure Monitors	3-23
3.5.5 Velocity Meter Operation	3-23
3.5.6 IRP Operation	3-23
3.5.7 Horizon Sensor Operation	3-23
3.6 Communications and Control	3-23
3.6.1 Range Safety System	3-24
3.6.2 Command System	3-26
3.6.3 Telemetry System	3-27
3.6.4 Tracking System	3-27
3.6.5 Instrumentation	3-27
3.7 Reliability	3-28
3.7.1 Agena Flight Data	3-28
3.7.2 Analysis	3-28
3.8 Aerospace Ground Equipment	3-29
3.8.1 Countdown	3-29
3.8.2 Pad Damage	3-29
4 CONCLUSIONS AND RECOMMENDATIONS	4-1
4.1 Conclusions	4-1
4.2 Recommendations	4-2

ILLUSTRATIONS

Figure		Page
2-1	Altitude Time Histories, GATV 5004	2-3
2-2	Latitude vs. Longitude Time Histories, GATV 5004	2-4
3-1	Wind Velocity Profiles, Atlas/GATV 5004	3-2
3-2	Wind Azimuth Profiles, Atlas/GATV 5004	3-3
3-3	Flight Accelerometers, GATV 5004	3-5
3-4	Accelerometer Activity Prior to BECO, GATV 5004	3-5
3-5	Atlas/GATV 5004 Separation	3-8
3-6	Horizon Sensor Fairing Temperature Time History, GATV 5003 and 5004, Measurement A210	3-9
3-7	Target Docking Adapter Temperature Time History, GATV 5003 and 5004, Measurement A394	3-10
3-8	Fiberglass Shroud Temperature Time History, GATV 5003 and 5004, Measurements AD044 and AD045	3-11
3-9	Electrical Power System Performance, GATV 5004	3-15
3-10	Start of Anomaly, Electrical Power System Performance, GATV 5004	3-16
3-11	Rates During Pitchover, GATV 5004 Flight Data	3-21
3-12	Range Safety System Operation, GATV 5004	3-25

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TABLES

Table		Page
S-1	Summary of Significant Events, Atlas/GATV 5004	ix
2-1	Radar Mode of Track, Atlas/GATV 5004	2-1
2-2	GATV 5004 Weight Data	2-5
3-1	Accelerometer/Telemetry Characteristics, GATV 5004	3-6
3-2	Steady-State Accelerations – A5 (Pitch), GATV 5004	3-6
3-3	Prelaunch Data, GATV 5004	3-14

xiv

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ABBREVIATIONS

ACS	Attitude Control System
AFETR	Air Force Eastern Test Range
AGE	Aerospace Ground Equipment
AVTW	Agena Vehicle Time Word
BAC	Bell Aerosystems Corporation
BECO	Booster Engine Cutoff
DRAPE	Data Reduction
EST	Eastern Standard Time
F/C	Flight Control
FCLP	Flight Control Logic Package
GAT	Gemini Agena Target orbital stage
GATV	Gemini Agena Target Vehicle second stage, including adapter section, payload firing, and other droppables
GD/C	General Dynamics/Convair.
GE	General Electric Company
GG	Gas Generator
GGFSV	Gas Generator Fuel Solenoid Valve
GGOSV	Gas Generator Oxidizer Solenoid Valve
GMT	Greenwich Mean Time
H _e	Helium
H/S	Horizon Sensor
IRFNA	Inhibited Red Fuming Nitric Acid
IRP	Inertial Reference Package
LMSC	Lockheed Missiles & Space Company
LOS	Loss of Signal
LOX	Liquid Oxygen

XV

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MAP	Message Acceptance Pulse
MDF	Mild Detonating Fuse
N ₂	Nitrogen
ODPS	Oxidizer Discharge Pressure Switch
OMPS	Oxidizer Manifold Pressure Switch
PAFB	Patrick Air Force Base
PCM	Pulse Code Modulation
PDT	Pacific Daylight Time
PFRT	Preliminary Flight Rating Tests
PHCV	Pyrotechnic Helium Control Valve
PIV	Propellant Isolation Valve
POSV	Pyro-Operated Solenoid Valve
PPS	Primary Propulsion System
PRF	Pulse Repetition Frequency
PTVA	Propulsion Test Vehicle Assembly
RTC	Real Time Command
SCCM	Standard Cubic Centimeters per Minute
SDP	Status Display Panel
SECO	Sustainer Engine Cutoff
SEP	Separation of the GAT from the Atlas Booster
S/N	Serial Number
SMRDD	Spin Motor Rotational Detector Device
SPC	Stored Program Command
SPS	Secondary Propulsion System
TCA	Thrust Chamber Assembly
TCP	Thrust Chamber Pressure
TCPS	Thrust Chamber Pressure Switch
TDA	Target Docking Adapter
TOS	Turbine Overspeed Switch
UDMH	Unsymmetrical Dimethylhydrazine
VECO	Vernier Engine Cutoff
V/M	Velocity Meter

xvi

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Section 1
INTRODUCTION

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Section 1 INTRODUCTION

1.1 PURPOSE AND SCOPE

This report was prepared as an evaluation of the flight performance of Gemini Agena Target Vehicle (GATV) 5004, which was launched from Complex 14, Cape Kennedy, Florida, on 17 May 1966.

The report documents the analysis of all data available for evaluation of flight performance. Atlas-derived data are discussed, where applicable, to the extent made known to Lockheed Missiles & Space Company (LMSC). The General Dynamics/Convair (GD/C) report on Atlas performance should be consulted for detailed performance data.

In Section 2, flight performance is discussed in detail. Section 3 presents Gemini Agena Target Vehicle subsystem performance data. Conclusions and recommendations are presented in Section 4.

1.2 GATV OBJECTIVES

Objectives of the GATV 5004 flight test were as follows:

- Provide a five-day active orbital life
- Provide an attitude control system that would operate with a control gas pressure as low as 400 psi
- Provide a restartable primary propulsion system capable of at least five starts
- Provide a secondary propulsion system that would operate with tank pressures as low as 1110 psi

- Provide a communications and command system capable of executing a minimum of 1000 commands (stored-program, real-time, or a combination of both)
- Provide a total system that would consume power at a rate not to exceed 450 w average

1.3 COUNTDOWN

The countdown was initiated at Complex 14, 17 May 1966 at 0000 EST or 600 min before Atlas/GATV liftoff. No vehicle anomalies were experienced during countdown. However, a hold of approximately 15 min was caused by a facilities problem during IRFNA loading. Section 3.8 gives further details on the problem. Weather conditions and surface winds were satisfactory for launch. Liftoff (2-in. motion) occurred at 1515:03.422 GMT (1015:03.422 EST).

1-2

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Section 2
FLIGHT PROFILE

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Section 2
FLIGHT PROFILE

Gemini Agena Target Vehicle (GATV) 5004 was launched from Complex 14 at an azimuth of 83.85 deg east of north.

2.1 Radar Tracking

C-band radar was received from four AFETR tracking stations – Patrick Air Force Base (0.18), Merritt Island (19.18), and Grand Bahama Island (3.16 and 3.18).

Table 2-1 is a compilation of extractions from the radar log information accompanying the data.

Table 2-1
RADAR MODE OF TRACK, ATLAS/GATV 5004

Radar	From (sec)	Through (sec)	Mode of Track
0.18	12.00	141.00	Auto-beacon
	141.00	142.60	Auto-skin
	143.05	146.50	Auto-skin
	146.50	147.00	Auto-beacon
	147.00	147.50	Search
	147.50	153.80	Auto-beacon
	154.70	313.95	Auto-skin
	314.00	365.50	Auto-skin
19.18	11.7	100	Auto-skin
	100	180	Auto-beacon
	180	344.4	Auto-skin
3.16	67.6	437.0	Auto-beacon
3.18	73.2	454.0	Auto-beacon
<u>Radar Coverage</u>			
0.18 = Patrick Air Force Base			
19.18 = Merritt Island			
3.16 } = Grand Bahama Island			
3.18 }			

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Significant departures from the planned ascent trajectory resulted when the booster engine (B-2) went hard over at 120.68 sec after liftoff. A post-flight reconstruction was not attempted since aerodynamic drag effects are not included in the available computer program.

No perturbation was noted in the Agena at the time the booster engine went hard over. The 0.18 and 19.18 radar stations are separated by only 12 mi and the respective elevation angle histories indicated that both were tracking the same target. Similarly, the 3.16 and 3.18 radar data indicated these stations also were tracking the same target, but not necessarily the same as tracked by 0.18 and 19.18.

The altitude histories derived from the 0.18 and 3.18 radar data are presented with the planned nominal for comparison in Fig. 2-1. Latitude versus longitude plots from the same sources are given in Fig. 2-2. Essentially identical plots were obtained from the 19.18 and 3.16 radar data, respectively.

From these plots, both 0.18 and 3.18 radars describe the same trajectory up to approximately 145 sec. This trajectory was in satisfactory agreement with the planned nominal. Radar gave no indication of a problem prior to this time. Subsequently, the 0.18 and 3.18 radars were tracking separate objects. Both departed significantly from the nominal.

The 3.18 C-band radar was on auto-beacon continuously during the time span of Figs. 2-1 and 2-2. Since the C-band beacon is on the GATV, it was concluded that the 3.18 tracking data refers to the GATV 5004 trajectory. Start of separation of the GATV from the SLV-3 (Atlas) occurred at 301.68 sec after liftoff. From the 3.18 radar, it is estimated that the GATV impacted at approximately latitude 28.88°N, longitude 78.85°W.

According to the sequence times given in Table S-1, booster engine separation occurred at 134.10 sec after liftoff. The 0.18 radar was on auto-skin track mode after

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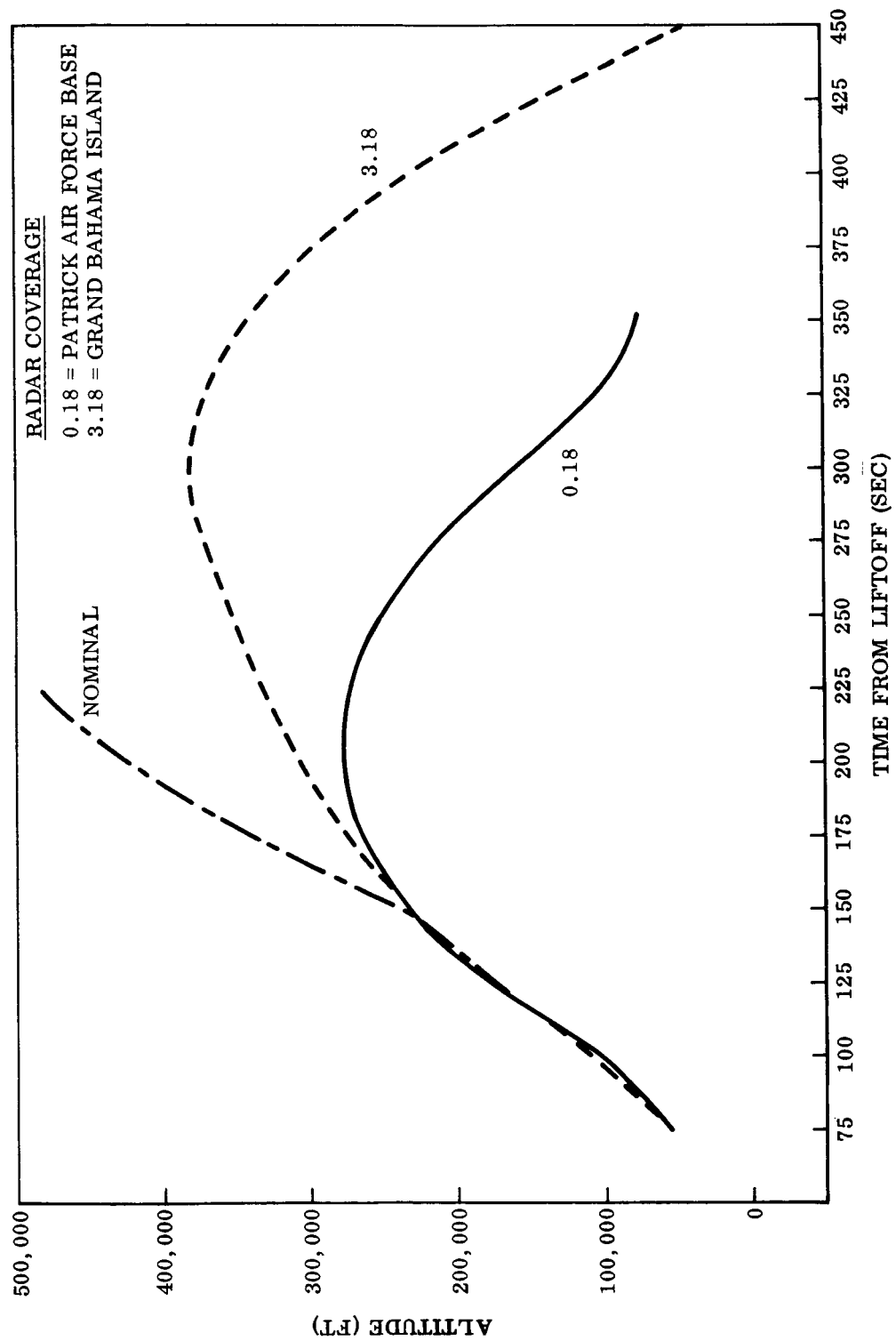


Fig. 2-1 Altitude Time Histories, GATV 5004

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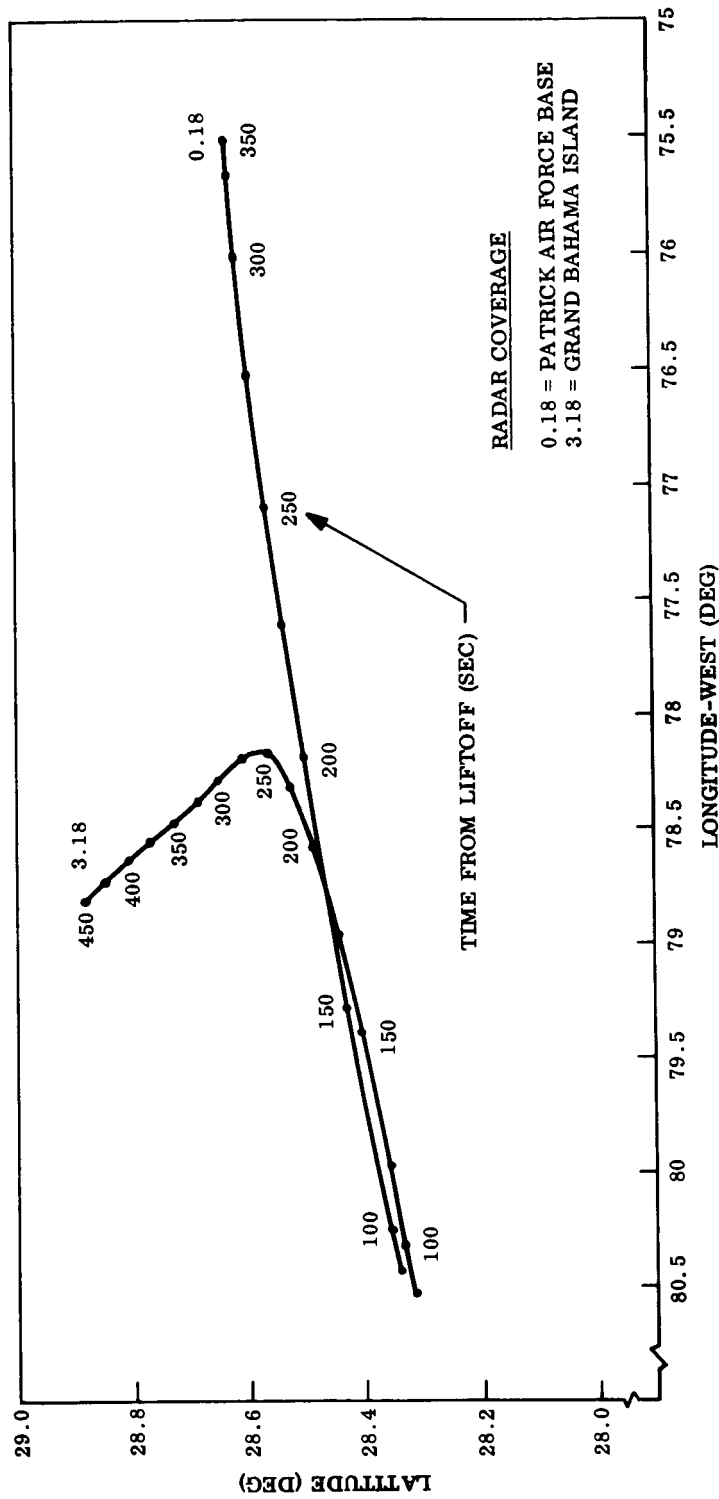


Fig. 2-2 Latitude vs. Longitude Time Histories, GATV 5004

2-4

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this time. Also, the trajectory indicated by the plots of Fig. 2-1 is consistent with an inert body in free fall. It is concluded that the 0.18 radar was tracking the booster engine. It is estimated that booster engine impact occurred at approximately latitude 28.63° N, longitude 75.50° W.

The General Electric Mod III radar data was also received. These data confirmed the near nominal trajectory up to loss-of-signal at approximately 130 sec after liftoff.

2.2 WEIGHT DATA, GATV 5004

Weight data for GATV 5004 are presented in Table 2-2.

Table 2-2
GATV 5004 WEIGHT DATA

	<u>lb</u>
GATV weight empty	4,012
Total propellants and gases loaded	14,017
Gross weight - Atlas payload	18,029
Less: Booster adapter and extension	-382
Self-destruct items	-11
Separation detonator and charge	-1
Retrorockets	-10
Horizon sensor fairings	-7
Separation weight	17,618

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Section 3
GATV SUBSYSTEM EVALUATION

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Section 3 GATV SUBSYSTEM EVALUATION

3.1 STRUCTURES

The instrumentation for GATV 5004 consisted of two accelerometers, an Atlas/GATV separation monitor, a nose-cone separation monitor, and 19 temperature measurements. Analysis of these measurements substantiates that an anomaly occurred during the Atlas boost phase of the flight.

The Atlas/GATV separation monitor indicated that final step function of separation occurred at 303.87 sec after liftoff. All temperature measurement devices and both accelerometers functioned properly.

3.1.1 Launch Wind Environment

The wind environment was monitored during the Gemini IX prelaunch period starting with a forecast two days prior to the launch and continuing at intervals with rawinsonde wind data until the final sounding balloon was released at 1500:00 GMT on the day of launch. Figures 3-1 and 3-2 present three wind velocity profiles and the corresponding wind azimuths as a function of altitude; these profiles were measured by balloons released at approximately 3, 1-1/4, and 1/4 hr before launch. As indicated by the shape of these profiles, the winds were relatively stable over this 3-hr period prior to launch. Computer analysis of these profiles indicated that the winds aloft would not create a loading or critical control situation.

3.1.2 Structural Loads

The boost phase of flight up to the time of booster anomaly appears to have been nominal with no significant loading conditions other than the wind response previously described.

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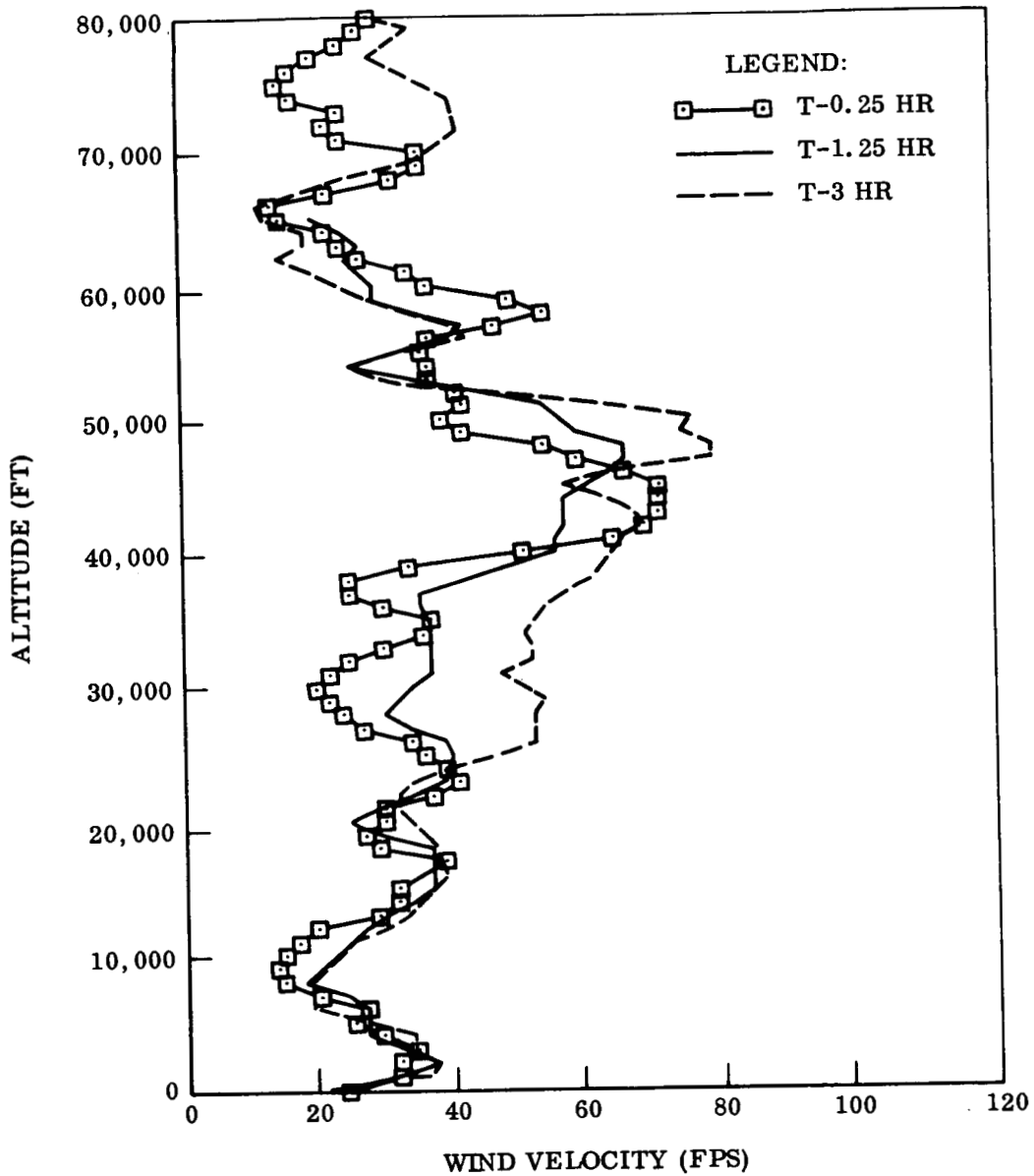


Fig. 3-1 Wind Velocity Profiles, Atlas/GATV 5004

3-2

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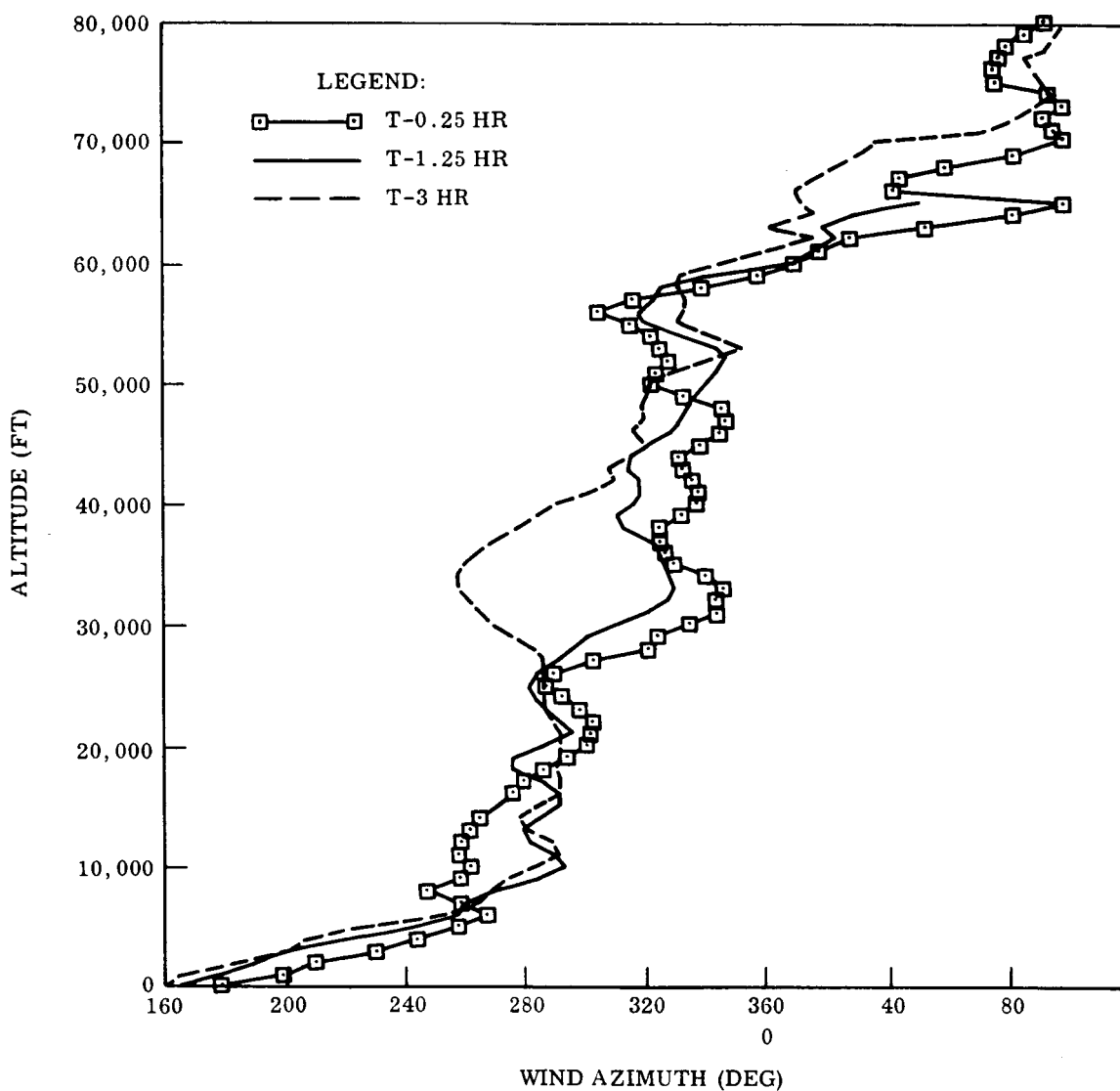


Fig. 3-2 Wind Azimuth Profiles, Atlas/GATV 5004

3-3

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At the time of the anomaly, which caused a rapid pitch down of the vehicle, the vehicle loading increased with the rate of rotation as the angle-of-attack increased to 90 deg. Analysis indicates the maximum bending moment occurred approximately 128 sec after liftoff at an angle-of-attack between 80 and 90 deg and had a magnitude of approximately 1,000,000 in.-lb at Station 585. This total bending moment is based on a dynamic pressure history taken from the performance post-flight simulation, rotational rates based on an extrapolation of the basic data beyond the "out of band" area, and the aerodynamic forces created by the pitch rate which acted upon the vehicle in such a manner as to increase this rate of pitch. The total loading during this time therefore included the moment due to an approximation of the airload, the relieving deceleration load, the relieving rotational rate and the axial acceleration from the booster engines. The ultimate capability of the vehicle at Station 585 is 1,300,000 in.-lb at BECO.

A comparison of the applied load to the vehicle capability indicates that a failure of the primary structure should not occur. A comparison of the computed lateral acceleration created by the rotational rates and airloading generally agrees with the lateral accelerometer data from the flight. This comparison indicates that the angle-of-attack was in the range of 90 deg at 128 sec and that the assumed increase in pitch rate due to airloading was reasonable.

3.1.3 Structural Dynamics

A description of the flight accelerometers and associated telemetry which were used on GATV 5004 is shown in Fig. 3-3 and Table 3-1. The behavior of these instruments during the first 120 sec of the ascent phase is quite normal and is essentially the same as the response recorded from the previous flight.

During the next 11 sec, the pitch accelerometer (A5) showed a rigid body acceleration time history. (See Table 3-2.) At about $t = 130$ sec considerable activity was noted on the accelerometer traces. This activity is given in Fig. 3-4, where it is represented by an envelope enclosing the commutated data points.

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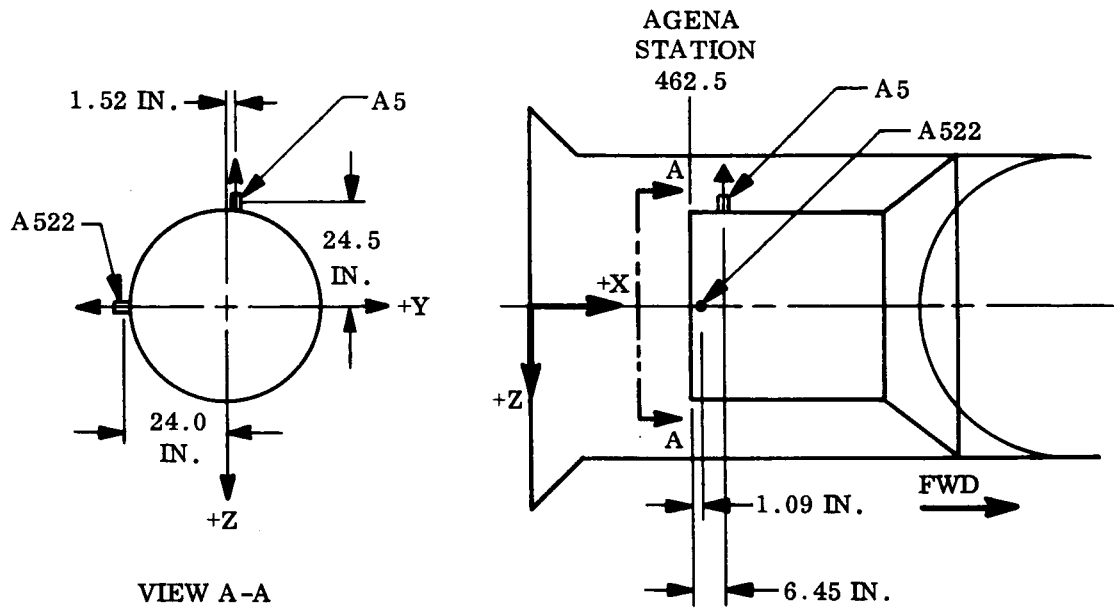


Fig. 3-3 Flight Accelerometers, GATV 5004

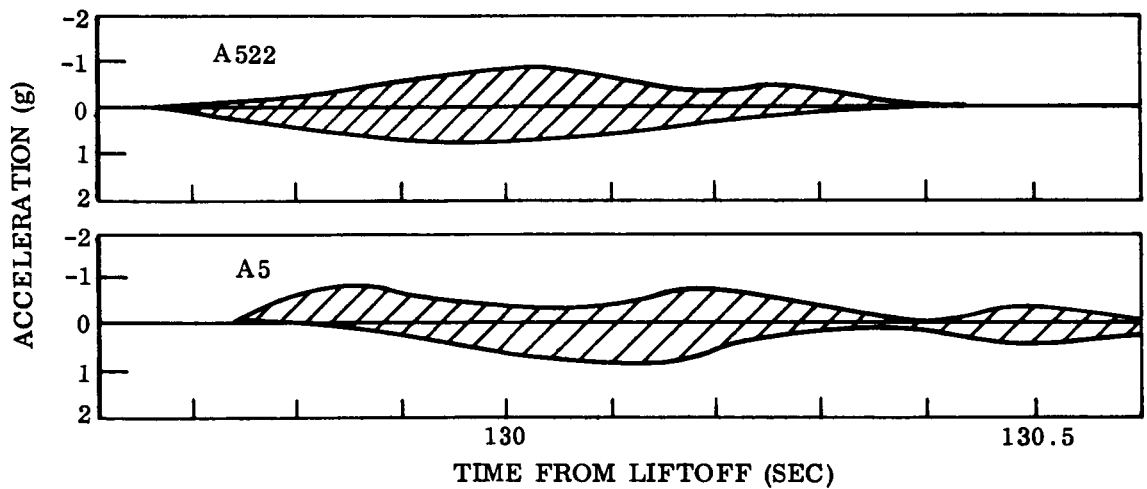


Fig. 3-4 Accelerometer Activity Prior to BECO, GATV 5004

Table 3-1
ACCELEROMETER/TELEMETRY CHARACTERISTICS, GATV 5004

Description					Telemetry		
Accelerometer Identification No.	Axis	LMSC Part No.	Range (g)	Range of Sensitivity ^(a) (cps)	PCM Sample Rate (samples/sec)	Polarity	
						Range Limits (g)	Calib. Limits (v)
A522	Y	1354540-515	±5.0	0 to 15	64	+3.5	0
						-3.5	5
A5	Z	1354540-515	±5.0	0 to 15	64	+3.5	0
						-3.5	5

(a) System Limitation.

Table 3-2
STEADY-STATE ACCELERATIONS - A5 (PITCH), GATV 5004

Time from Liftoff (sec)	Acceleration (g)
120	0
121	0
122	0
123	0.1
124	0.2
125	0.25
126	0.35
127	0.45
128	0.50
129	0.45
130	0.20
131	0
131.21	0

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Accelerometer activity following booster staging is very uncertain. Data dropout out-of-band readings, and zero shift of the Y-axis accelerometer (A522) typify the traces taken during this phase of flight, from $t = 134.1$ sec to about $t = 140$ sec. The activity of the commutated data points at Atlas/GATV separation indicates that the zero shift of accelerometer A522 jumps from about 0.2 to 0.8 g.

3.1.4 Separation Dynamics

The Atlas/GATV separation event was initiated 301.6 sec after liftoff and separation was apparently nominal. Based on the data received, the GATV was free of the Atlas adapter 2.2 sec after initiation of the separation event. (See Fig. 3-5.) Extrapolation of the data shows that the engine core should have cleared the adapter forward joint approximately 2.8 sec after initiation. The apparent relative velocity between the Atlas and the GATV was 46.3 in./sec.

3.1.5 Thermodynamics

All prelaunch liftoff temperatures were normal, thereby indicating that the ground cooling air supplied prior to launch was adequate.

Because of the abnormal nature of the flight, a comparison was made between the flight data obtained from this vehicle (GATV 5004) and the essentially nominal flight of GATV 5003. Also, flight data from GATV 5004 was analyzed to determine if vehicle behavior could be inferred.

The following skin temperature instrumentation was employed on GATV 5004: one resistance thermometer was located on the inner surface of the horizon sensor fairing, four thermistors were mounted on Station 210 on the skin of the target docking adapter, and six resistance thermometers were mounted on the inner surface of the fiberglass shroud. The data from measurements A210, A394, AD044 and AD045 on GATV 5003 and GATV 5004 are presented in Figs. 3-6, 3-7, and 3-8 together with the corresponding design temperatures.

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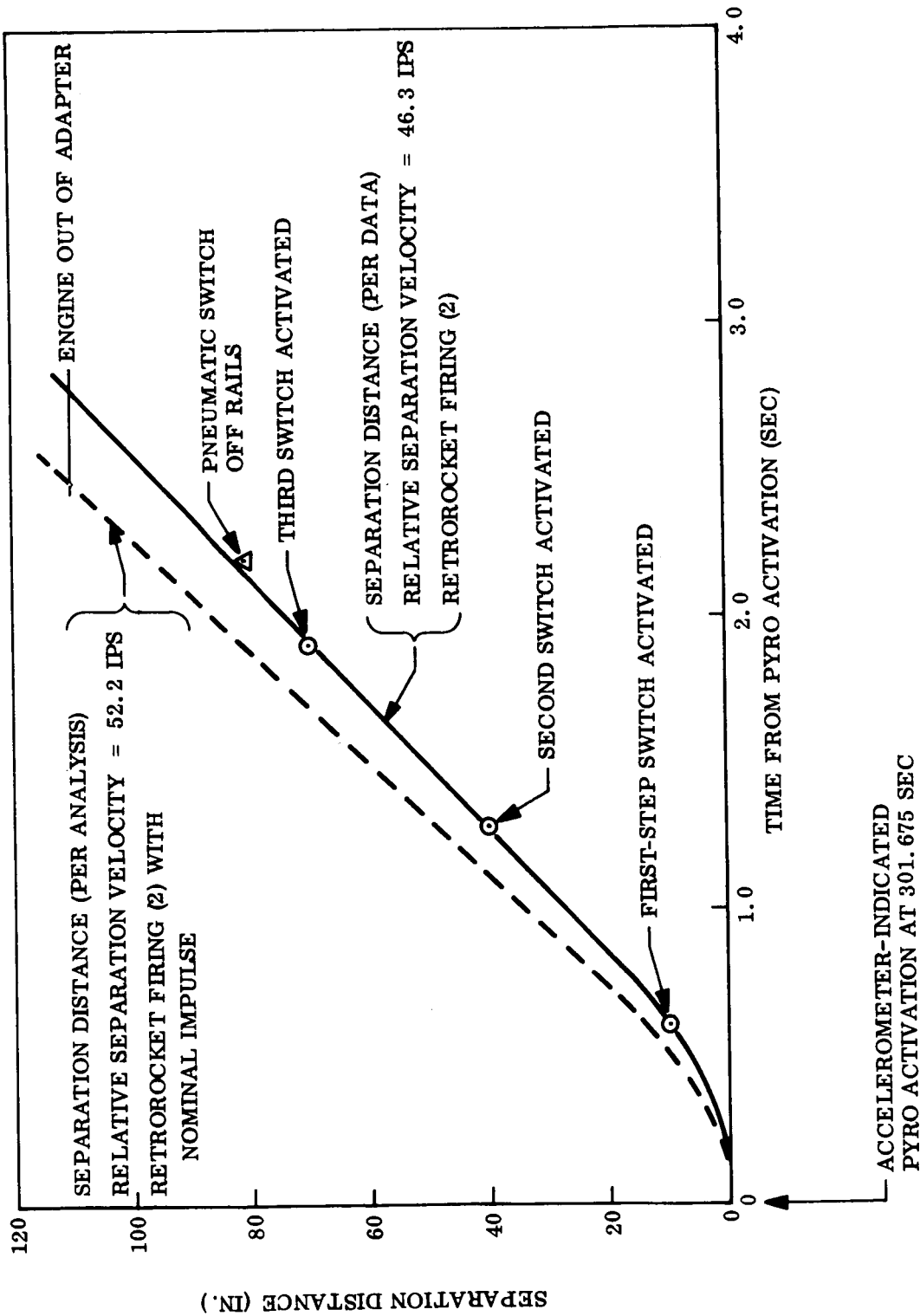


Fig. 3-5 Atlas/GATV 5004 Separation

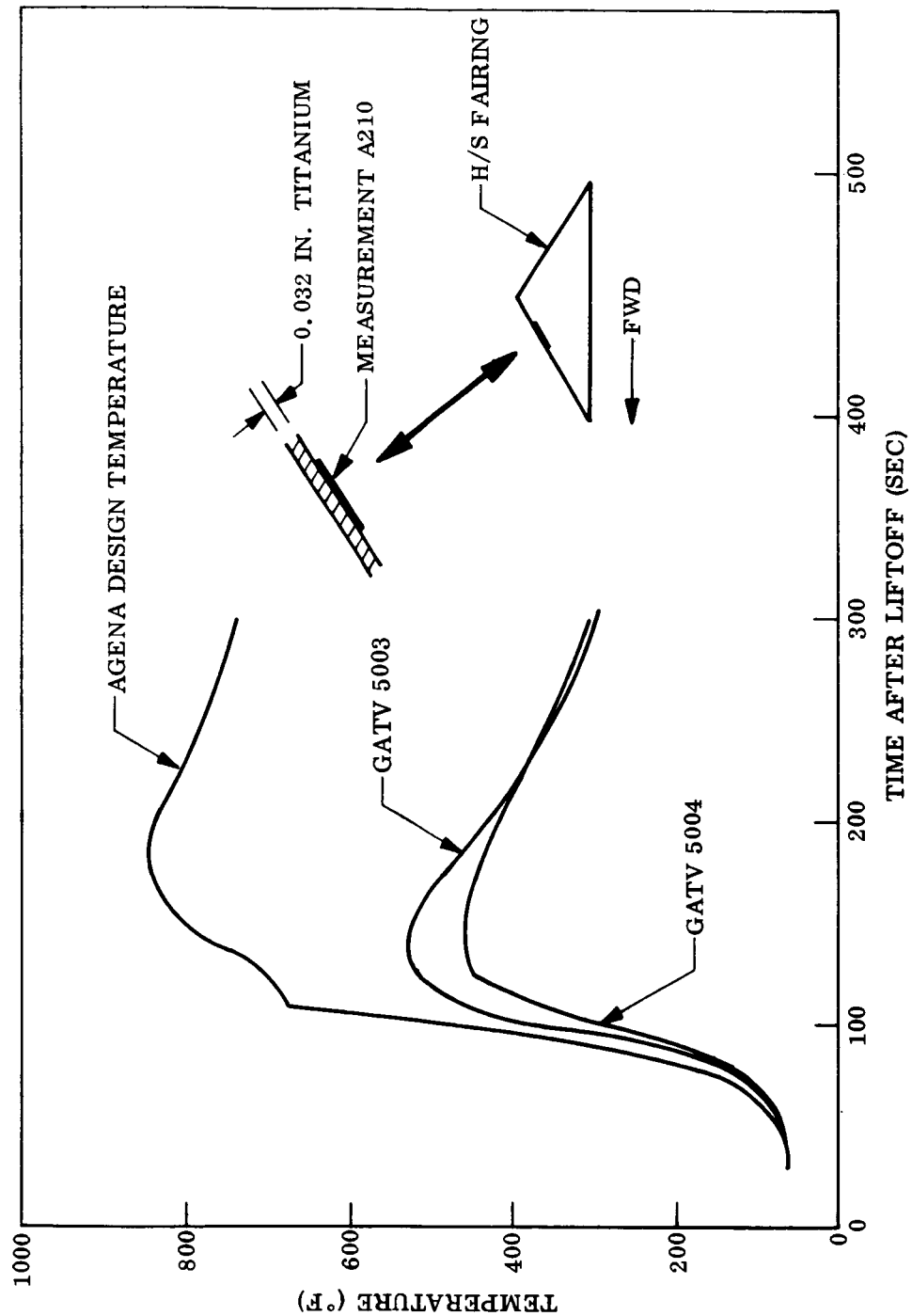


Fig. 3-6 Horizon Sensor Fairing Temperature Time History, GATV 5003 and 5004, Measurement A210

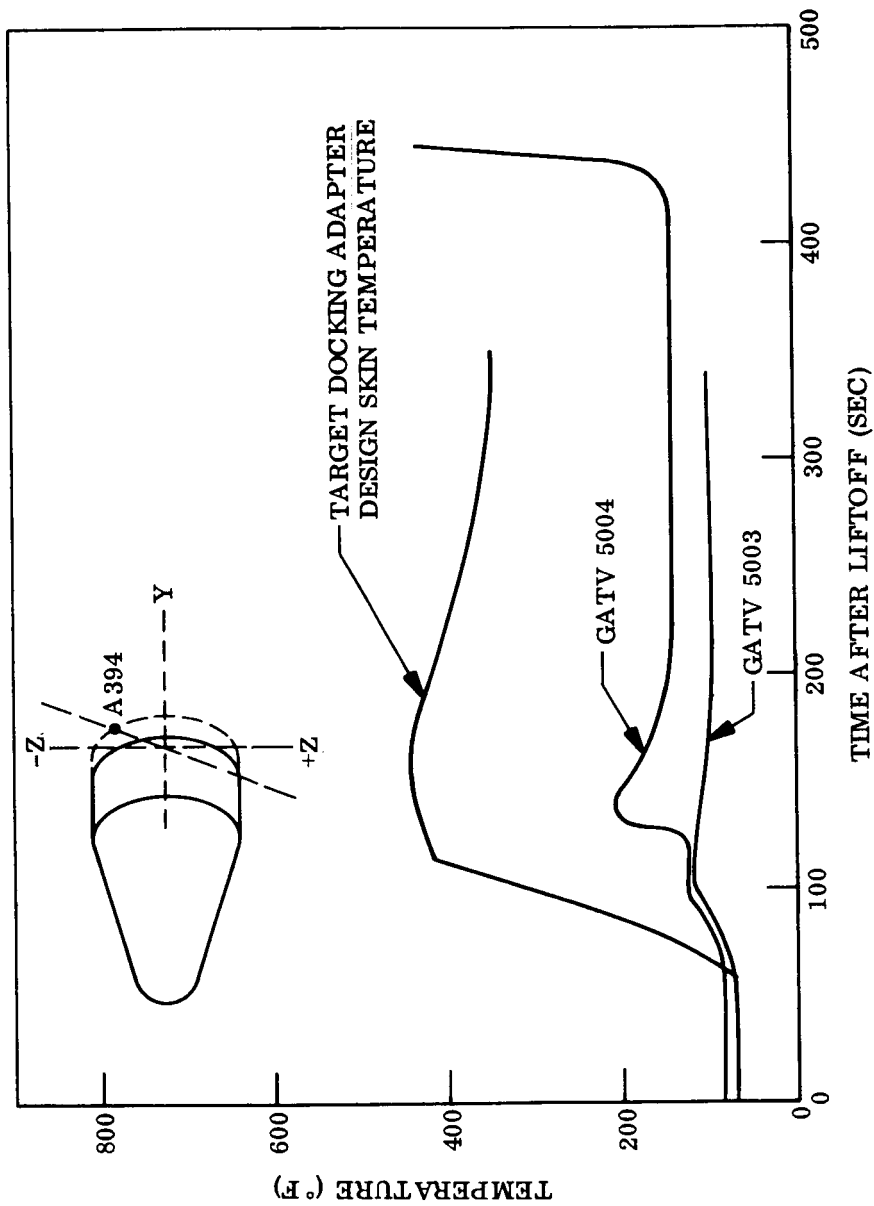


Fig. 3-7 Target Docking Adapter Temperature Time History, GATV 5003 and 5004, Measurement A394

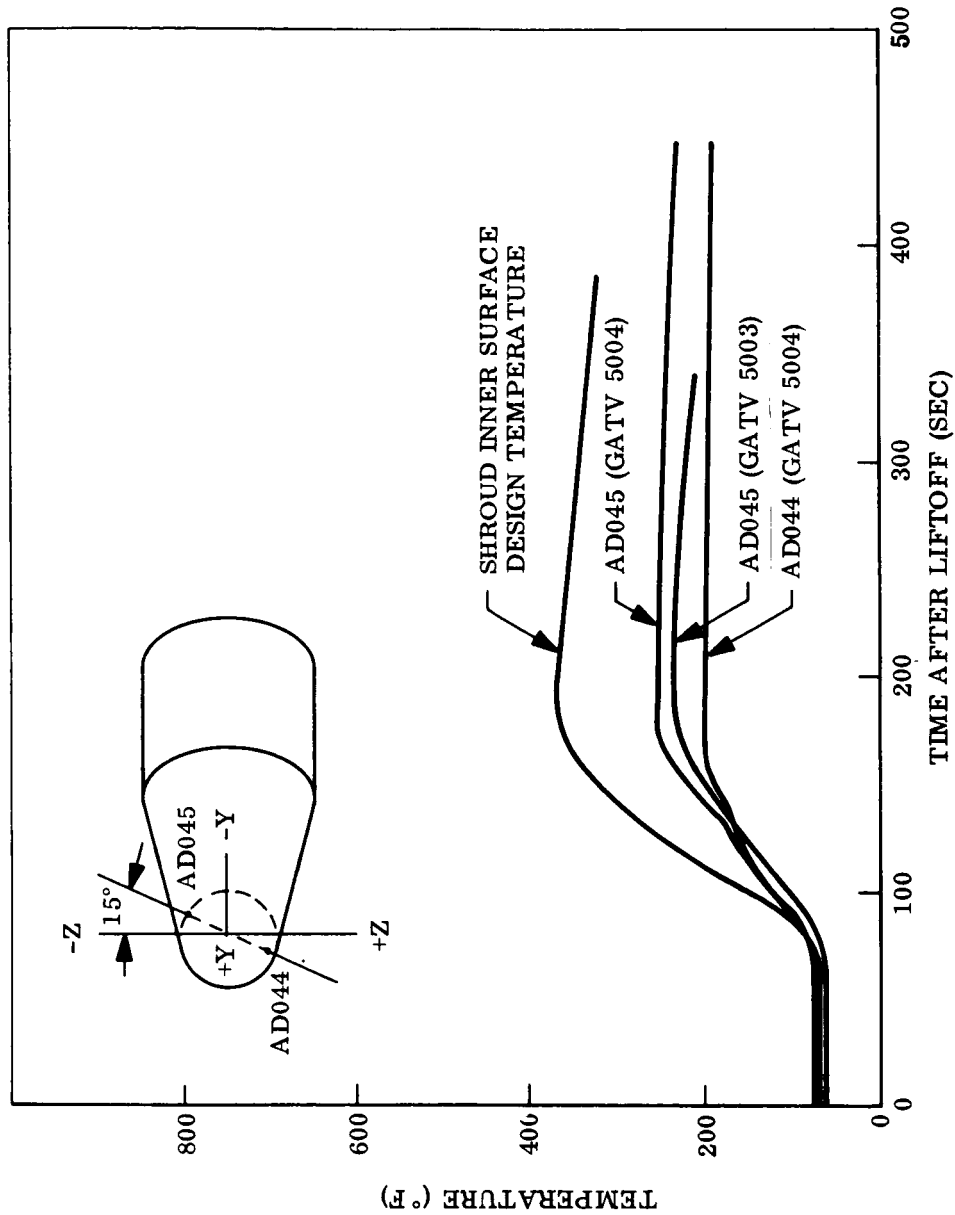


Fig. 3-8 Fiberglass Shroud Temperature Time History, GATV 5003 and 5004, Measurements AD044 and AD045

Until approximately 120 sec after liftoff, the temperature data from GATV 5004 was close to the corresponding data obtained from GATV 5003. After 120 sec the data from the four sensors on the skin of the target docking adapter show a sharp rise, indicating that the vehicle flew with large angles-of-attack (nose down). This interpretation is consistent with flight dynamic data.

The horizon sensor fairing temperature, shown in Fig. 3-6, was nominal for this flight. The measurement was lost at approximately 300 sec, indicating jettisoning of the fairing.

All instrumented equipment and internal structures, with the exception of the 400-cps, 3-phase inverter, experienced normal temperature histories up to approximately 410 sec after liftoff. The 400-cps, 3-phase inverter experienced an unusually high temperature rise from 150 sec after liftoff until the end of telemetered data.

From approximately 410 sec after liftoff to the end of telemetered data, severe temperature increases were experienced by exposed instrumented equipment and structures, indicating high heat rates caused by reentry aerodynamic heating.

3.2 SECONDARY PROPULSION SYSTEM

All pressures and temperatures associated with the Model 8250 secondary propulsion system (SPS) were normal during the prelaunch and boost phase of the flight.

The secondary propulsion system received no signal from the ascent sequence timer to initiate ullage orientation.

All parameters remained normal during ascent until approximately 410 sec into the flight. A slight decrease in liquid (oxidizer and fuel feed) pressures was noted at approximately 274 sec due to loss in acceleration head at SECO. Between 410 and 430 sec all SPS temperatures began to rise; at 431 sec all SPS pressures began to rise. A 3 to 5 psi, cyclic rise was observed in all four thrust chambers, indicating erratic motion during reentry. All parameters continued to rise until loss of data.

3.3 PRIMARY PROPULSION SYSTEM

Propulsion system parameters appeared nominal through SECO. Since the ascent sequence timer was not initiated, the primary propulsion system (PPS) received no signal to fire. From approximately 410 sec after liftoff to loss-of-signal, PPS temperature transducers showed an increase in temperature due to reentry aerodynamic heating.

The post-flight data indicated all propellant and gas quick disconnects sealed at liftoff. Table 3-3 shows the prelaunch status of propellants and gases loaded aboard vehicle GATV 5004.

3.4 ELECTRICAL POWER SYSTEM

The electrical power system performance was nominal up to approximately 130.5 sec. (See Figs. 3-9 and 3-10.) At this time, current transients were observed on the main bus current monitor, which continued until 131.247 sec, at which time a steady value

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Table 3-3
PRELAUNCH DATA, GATV 5004

<u>Item</u>	<u>Parameter</u>	<u>Actual Value</u>	<u>Specification Limits</u>
1	Helium sphere pressure	2447 psia	2150 to 2500 psia
2	Helium sphere temperature	56.3° F	50 to 120° F
3	Ox. start tank load	18.4 cu in.	18.4 ± 0.3 cu in.
4	Ox. start tank temperature:		
	At loading	72° F	32 to 90° F
	At launch	57° F	32 to 90° F
5	Fuel start tank load	102.9 cu in.	103.0 ± 1.1 cu in.
6	Fuel start tank temperature:		
	At loading	75° F	35 to 115° F
	At launch	57° F	35 to 115° F
7	Ox. start tank pressure:		
	At loading	1028 psig	830 to 1155 psia
	At launch	1018 psia	830 to 1155 psia
8	Fuel start tank pressure:		
	At loading	1047 psig	825 to 1150 psia
	At launch	1017 psia	825 to 1150 psia
9	Main ox. tank pressure:		
	At launch	30.9 psig	30 to 32 psig
10	Main fuel tank pressure:		
	At launch	39.6 psig	38 to 40 psig
11	Ox. sump temperature:		
	At launch	54.5° F	45 to 60° F
12	Main fuel temperature:		
	At launch	55.8° F	45 to 60° F
13	Oxidizer lip-seal pressure		
	At launch	6.4 psig	2 to 20 psig
14	Propellant specific gravity:		
	Oxidizer	1.570 @ 60° F	None
	Fuel	0.7856 @ 77° F	None
15	Propellant Loading:		
	Oxidizer	9706 lb	9718 ± 0.25 %
	Fuel	3814 lb	3813 ± 0.25 %

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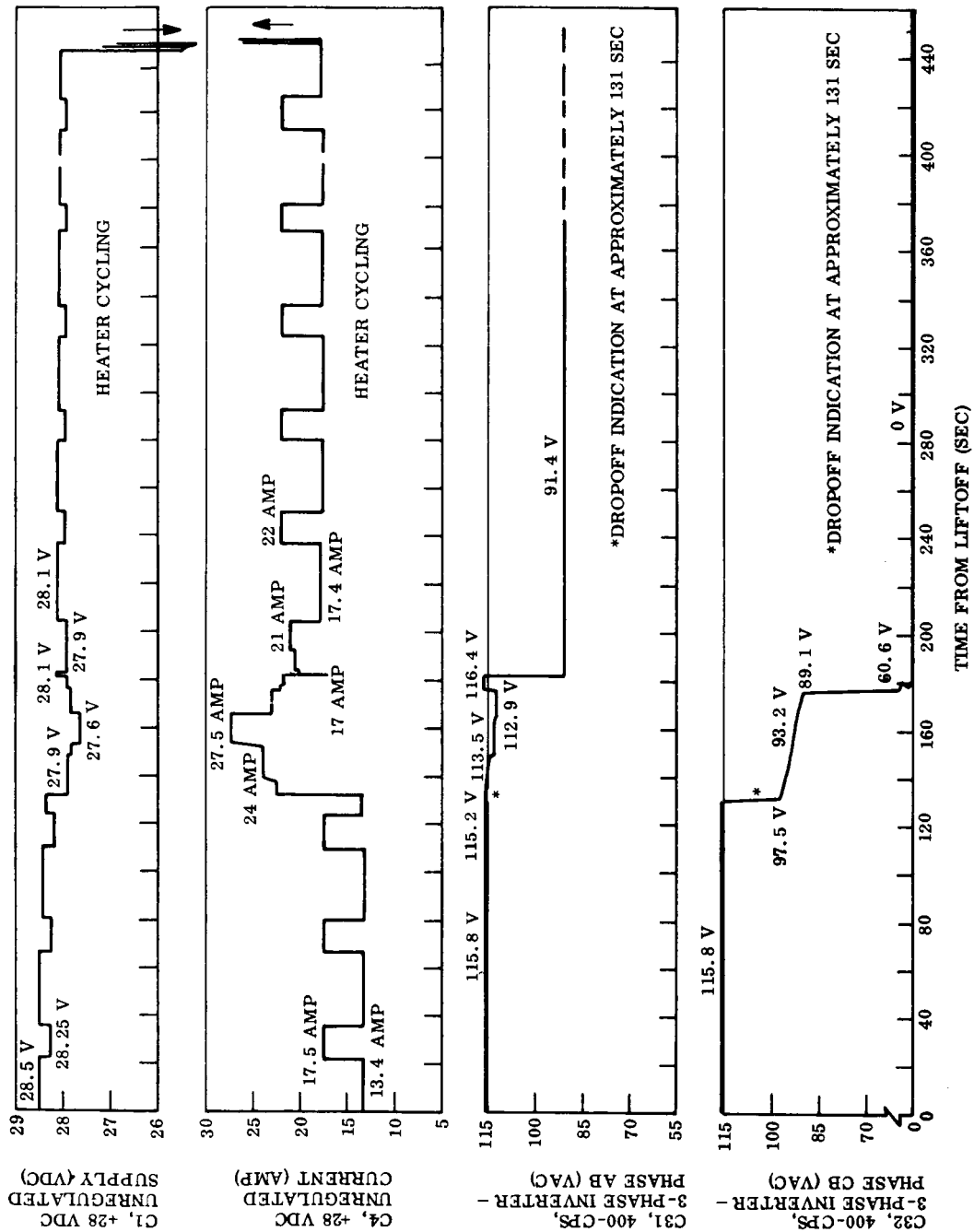


Fig. 3-9 Electrical Power System Performance, GATV 5004

3-15

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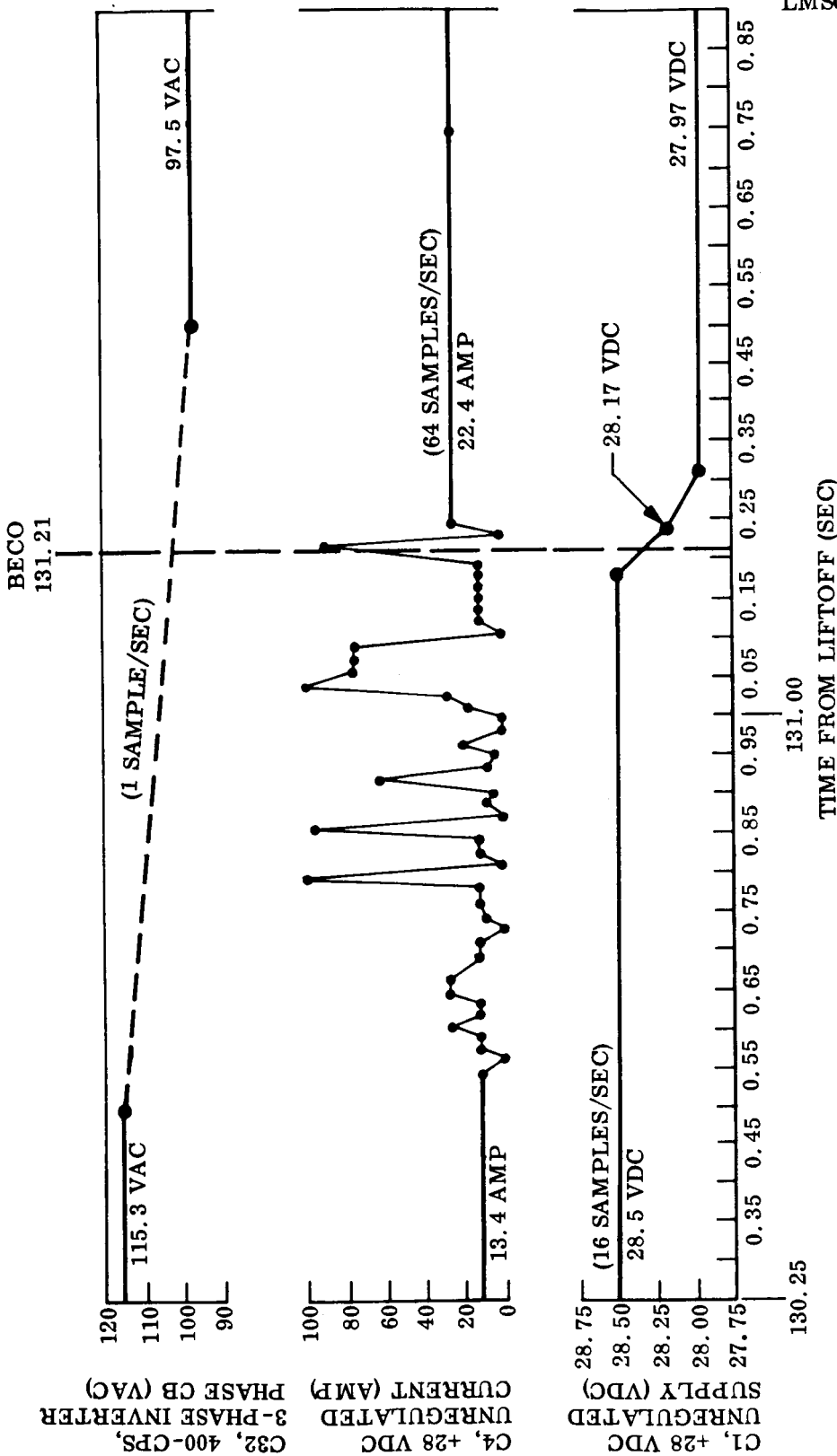


Fig. 3-10 Start of Anomaly, Electrical Power System Performance, GATV 5004

of 22.4 amp was indicated. At 131.247 sec, the main bus voltage dropped from 28.5 vdc to 27.97 vdc, and the pyro bus voltage dropped from 28.97 to 28.46 vdc, indicating an increased load on the electrical system although no vehicle function had occurred. This apparent load continued until 152.8 sec when the main bus current reached 27.5 amp, while the main bus voltage and the pyro bus voltage had dropped to 27.6 vdc and 28.26 vdc, respectively. This load level remained until 166.3 sec when the main bus current dropped to 23.9 amp and the main bus voltage increased to 27.8 vdc.

Current continued to decay to approximately 21 amp at 205 sec, and then cycled between 17.4 and 22 amp until LOS. This load was between 4 and 9 amp above the normal expected loads during this period. A current surge of 53.1 amp at approximately 299 sec, which was reflected on the pyro bus, indicating receipt of the Atlas discrete to eject the horizon sensor fairings.

During the time period 130.498 to 131.498 sec, phase BC of the 400-cps, 3-phase inverter dropped from 115.8 to 97.5 vac. Phase BC then decayed gradually to 89.1 vac at 175.50 sec. At 176.50 sec, phase BC dropped to 60.6 vac, and then to zero telemetry volts at 177.50 sec, which would indicate either an open circuit or a short to ground of phase BC.

Phase AB of the 400-cps, 3-phase inverter indicated voltages varying from 112.9 to 116.4 vac during the time period 149.50 to 181.50 sec. At 182.50 sec voltage dropped to 91.4 vac and remained at that level until LOS.

From 150 to 446 sec the 400-cps, 3-phase inverter temperature increased from 72.9° to 118.9° F, a change rate of approximately 10° F/min. The temperature sensor is located inside the inverter case to the left of C36J2 plug next to the transistor oscillator bank.

All other electrical parameters were either steady-state or followed nominal/predicted values during the entire data acquisition period.

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The Type XII-A 400-cps, 3-phase inverter performance indicated an output overload. This apparent overload can be explained by arcing from pins 2D and 2E of the J-100 umbilical causing transients in the phase system, which in turn caused an electrical failure in the system. This arcing is indicated by the early bus current transients prior to BECO. The resultant electrical failure then caused an overload which produced the observed performance of the system including the eventual partial failure of the Type XII-A inverter.

LMSC has experienced arcing at the 3-phase pins on J-100 on otherwise nominal thrust-augmented Thor/Agena flights. This arcing has never been linked with an in-flight failure, but laboratory simulations using a Type I inverter have produced capacitor failures in the IRP and subsequent inverter failures.

This arcing has never been observed on Atlas flights prior to GATV 5004. The possible arcing on this flight is attributed to the greatly increased ion density as the vehicle was flying backwards through the Atlas exhaust gases.

3.5 GUIDANCE AND CONTROL

The Guidance and Control system performance was evaluated for approximately 456 sec of flight or until data became unreadable. Normally the system would control vehicle flight from Atlas/GATV separation on, or for approximately the last 140 sec of this flight. On this flight, the 3-phase inverter power was lost prior to separation and the guidance and control system was operating without the inertial reference package (IRP) and the ascent sequence timer (AST).

Flight performance is evaluated in the following paragraphs.

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3.5.1 Event Monitors

The booster command monitor (D37) provided the following record of guidance events:

Time from Liftoff (sec)		Event
Nominal	Actual	
278.5	—	Sequence timer start
298.4	299.36	VECO, uncage gyros, fire H/S fairings
301.0	301.68	Start separation, pullaway plug (P700), start timer (backup)
303.5	303.88	Separation complete, S3 and S4 open
330.5	—	Uncage gyros (backup)
339.5	—	Remove uncage gyros (backup) signal

This comparison of actual versus nominal event times indicates that the AST brake power was not removed by discrete command from the booster at 278.5 sec. Instead, it was removed at 302.68 sec by the separation of the pullaway plug P700. Further, it appears that the AST counter did not start as there is no indication of the occurrence of the "uncage gyros" backup signal.

Additional evidence that the AST did not start is the fact that the system never received the pitch down (-1.5 deg/sec) program, nor at the completion of this program was the pitch H/S connected to the pitch gyro.

Since the AST motor runs on 3-phase power there is a definite correlation between the power anomaly and the timer problem.

3.5.2 Vehicle Motion/Control Performance

The attitude control system (ACS) was not activated until Atlas/GATV separation. During this time the gyros are in a caged configuration and sense vehicle rates. The horizon sensor (H/S) system does not provide a reference to the IRP until just prior to separation when the H/S fairings are ejected and the gyros are uncaged.

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Sixteen sec after liftoff the pitch gyro (operating as a rate gyro) indicated pitch over rates between -0.35 and -0.8 deg/sec. At 120.9 sec after liftoff (Fig. 3-11), the pitch gyro indicated a rapidly increasing negative rate which saturated the TM and/or the gyro at 123.1 sec, indicating a rate of greater than -3.5 deg/sec. The gyro remained in saturation until after BECO, going through 0 deg/sec rate at approximately 137.4 sec, and damping out thereafter. The pitch rates from 123.1 sec to approximately 137.5 sec were extrapolated due to TM saturation and data dropouts. Based on the rates indicated in Fig. 3-11, the pitch down resulted in a net pitch attitude change of approximately -146.9 deg.

At approximately 130.5 sec, the roll gyro detected roll rates up to 3.3 deg/sec along with roll oscillations. These oscillations damped out in approximately 40 sec. The roll channel then indicated stable operation until Atlas/GATV separation.

The yaw gyro sensed small vehicle oscillations from 132 to 175 sec. Oscillations in all cases were between 0.20 and 0.30 cps.

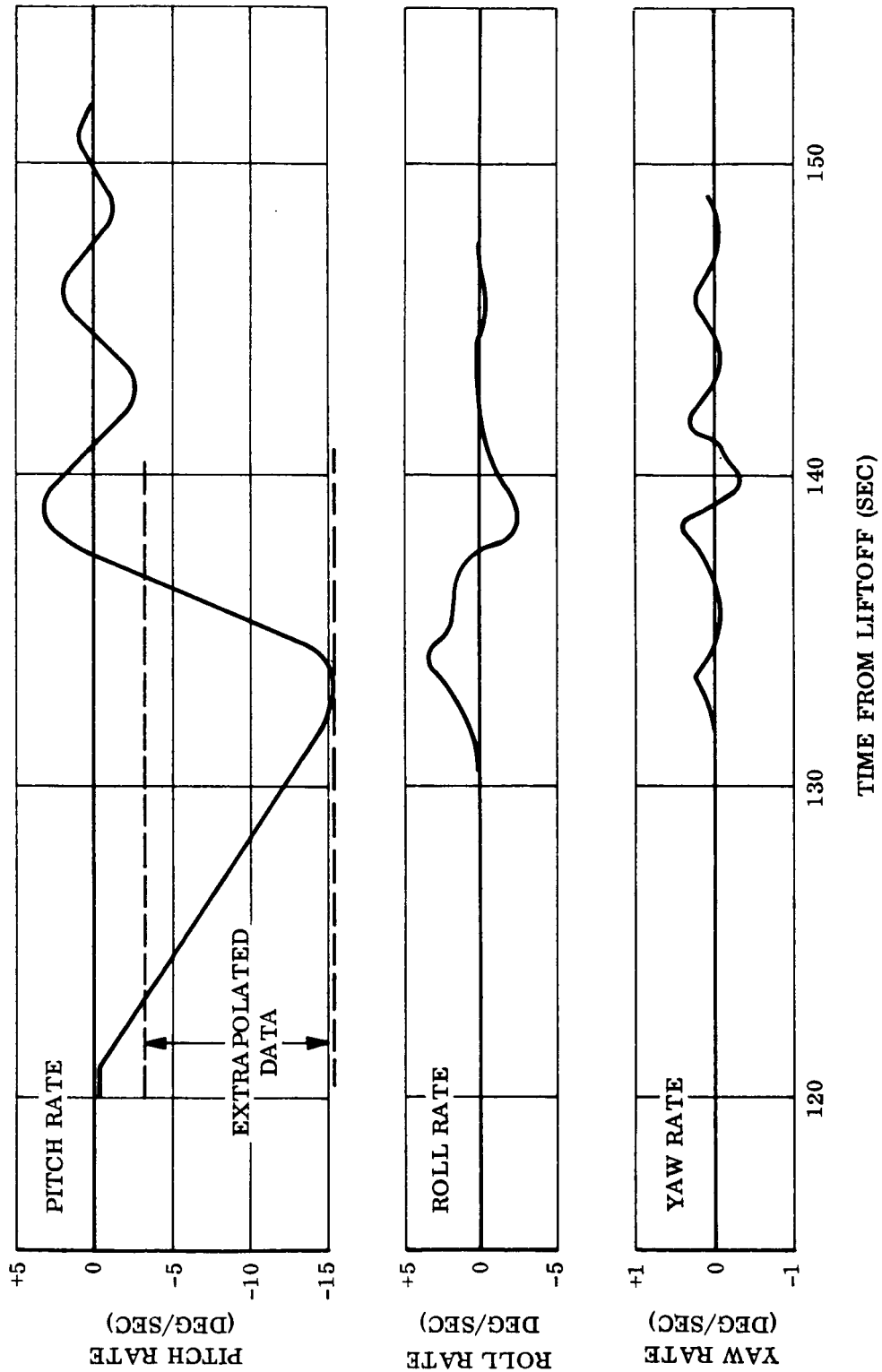
The spin motor rotational detection device (SMRDD) monitor went off at 179.4 sec and all gyro data from this time to loss-of-signal is invalid for analyzing vehicle motion. The SMRDD indication correlates with the loss of phase BC (60.4 vac) of the 400-cps inverter at 176.5 sec.

After the loss of the gyros, the only indication of vehicle motions and attitudes were the horizon sensors. At 299.36 sec the H/S fairings were ejected as indicated by the H/S roll and pitch outputs. The roll H/S indicated a relatively stable $+1$ deg position error at H/S fairing ejection, but at Atlas/GATV separation, the H/S indicated a -3.4 deg/sec rate. Similarly the pitch H/S indicated a stable, near null condition at H/S fairing ejection, but at Atlas/GATV separation, indicated a $+7.12$ deg/sec rate.

The roll H/S was connected to the roll gyro at the time and did torque the gyro. Gyro response was not normal but it did provide an error signal to the flight control electronics and resulted in pulsing of the gas valves. Gas valve activity started at 304.4 sec

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3-21

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Fig. 3-11 Rates During Pitchover, GATV 5004 Flight Data

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and the polarity was correct as referenced to the roll gyro output. Since the pitch H/S never was connected to the pitch gyro and the pitch gyro was not rotating, there was at most a few scattered pulses in the pitch axis.

The roll H/S indicated that the vehicle was oscillating following separation and was possibly rolling steadily. The pitch H/S went to positive TM saturation at separation and remained there until LOS.

3.5.3 Temperature Monitors

The guidance and control system temperature monitors indicated normal operating temperature throughout the flight until approximately 400 sec. At that time several of the temperature monitors indicated a temperature rise which apparently coincides with the vehicle reentering the atmosphere. Those monitors indicating temperature rise are the gas valve clusters and the hydraulic oil return line.

- Hydraulic oil return line temperature (D5):
Increased from 72° to 120° F at 420 sec to LOS
- Gas valve cluster No. 1 (D46):
Increased from 45.1° to about 150° F at 405 sec to LOS
- Gas valve cluster No. 2 (D47):
Increased from 43.6° to above 150° F at 418 sec to LOS
- H/S head temperatures (D54, D55):
Maintained approximately 70° F throughout flight
- Velocity meter (V/M) electronic oven temperature (D85):
Maintained 4.58-vdc TM reading throughout flight
- V/M accelerometer oven temperature (D87):
Maintained 4.70 to 4.80-vdc TM reading throughout flight
- IRP internal case temperature:
Varied between 139.4° and 142.6° F throughout flight

3.5.4 Pressure Monitors

All guidance and control pressure monitors appeared normal throughout the flight. The hydraulic oil high pressure (D60) indicated a rise beginning at 425.7 sec. This is

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the time period when heating was evident in the aft section and is probably a result of thermal expansion in the hydraulic high-pressure lines.

3.5.5 Velocity Meter Operation

There was no PPS engine burn during the flight, therefore there is no V/M operation to evaluate. The V/M stored word at liftoff was 15,841, which represents a velocity to be gained of 8235 fps.

3.5.6 IRP Operation

As mentioned previously, the IRP SMRDD monitor indicated incorrect IRP operation at 179.4 sec. This corresponds to the loss of 3-phase power. It must be assumed, therefore, that the gyro spin motors ran down and stopped and all gyro data after this time is invalid.

3.5.7 Horizon Sensor Operation

The H/S operation appears normal with the exception of the error sensed at BECO. During this latter period there did not appear to be any abnormally high H/S fairing temperature. Since the GATV was experiencing power problems at this point, a transient could result in an indication of this nature.

3.6 COMMUNICATIONS AND CONTROL

Data from the brief GATV 5004 flight period shows that all communications and control (C&C) equipment performed normally throughout the flight until LOS.

The most significant finding from the C&C data is that a partial RF blackout occurred between 130 and 142 sec. This blackout was such that the telemetry signal strength varied in a highly transient fashion about threshold allowing intermittent frames of

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main frame data during the period but not long enough (1 sec) to allow a complete subframe A. This type of activity tends to indicate variable ionization caused by exhaust gases.

The data also shows that the C- and S-band ground radars lost track of the beacon intermittently during this time and that some difficulty was experienced in re-acquiring track. This is further evidence that an ionization-caused RF blackout was in effect.

The loss of telemetry data from 130 to 142 sec was in the recording at both Cape Kennedy and Grand Bahama thus discounting the possibility that a ground tracking antenna malfunction had caused this tracking difficulty.

3.6.1 Range Safety System (See Fig. 3-12)

Measurements: H101 Safe Arm Fire No. 1
H103 Safe Arm Fire No. 2
H354 Destruct Receiver No. 1 Signal
H364 Destruct Receiver No. 2 Signal
H357 Destruct Receiver No. 1 Temperature
H367 Destruct Receiver No. 2 Temperature

An Agena range safety engine shutdown signal was sent from Cape Kennedy (CNV) at 1520:18 (t = 315 sec) and from Grand Turk Island (GTI) at 1520:41 (t = 338 sec).

From measurements H101 and H103, it is seen that Receiver No. 1 responded briefly to the CNV signal at 315 sec and Receiver No. 2 did not respond. At 342.7 sec Receiver No. 2 responded briefly to the GTI transmission and both receivers locked on solidly at 345.7 sec and remained locked on until 353.7 sec when the tones were shut off.

The reason for the sporadic behavior at 315 sec appears to have been the below-threshold signal strength at the receiver due to its range from CNV (about 225 nm).

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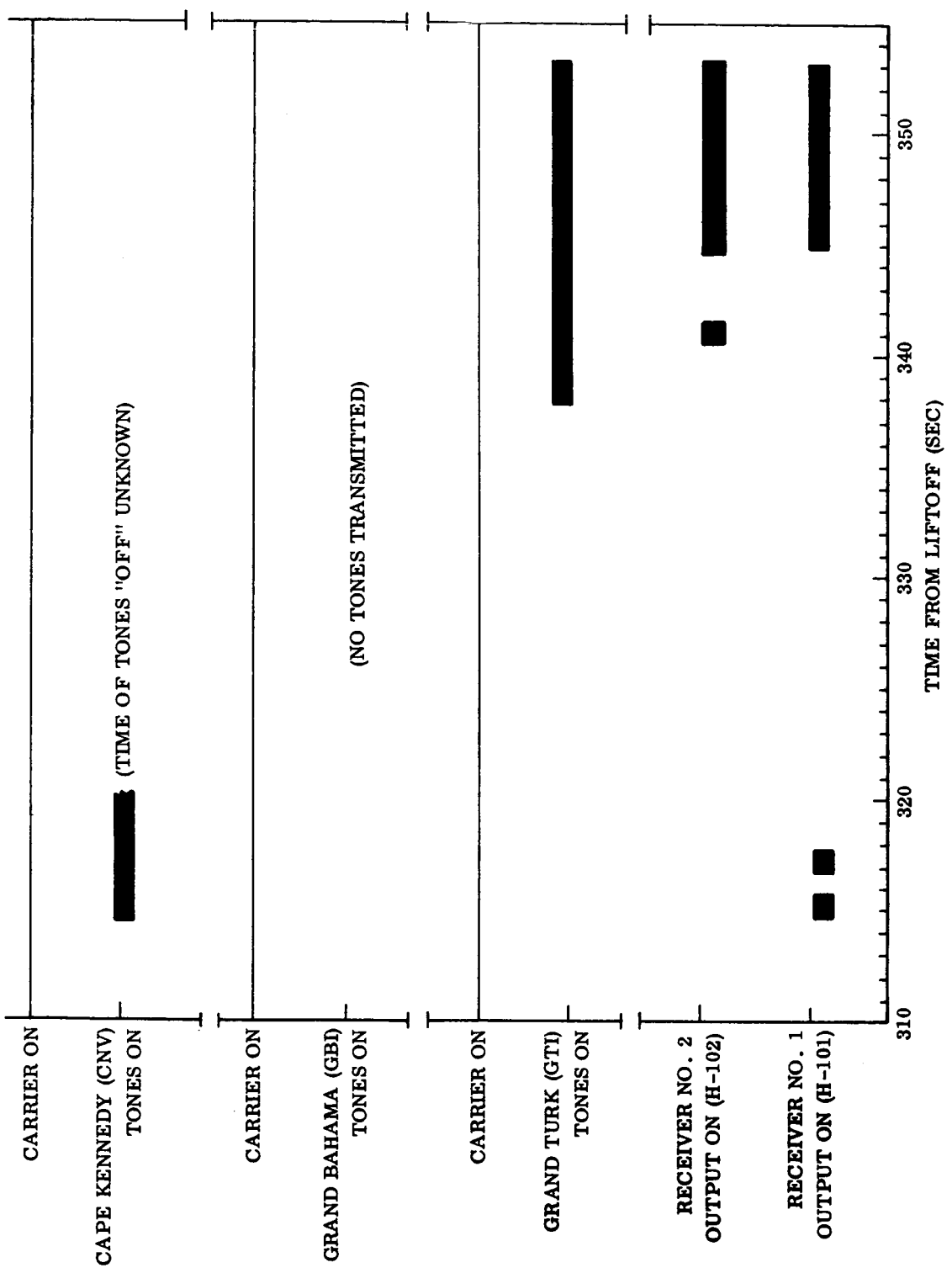


Fig. 3-12 Range Safety System Operation, GA TV 5004

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The signal strength readings H354 and H364 showed excellent signals but they were probably reflecting the Grand Bahama Island (GBI) carrier which was up at the time but not transmitting tones. The GATV was just coming into range of the GTI transmitter when the tones were transmitted from that site at 338 sec. Therefore, there was sporadic response until 345 sec when both receivers locked on solidly and remained on until the tones were shut off at 353 sec.

The design of the system is such that the first signal that caused an output (at 315 sec) effected the engine shutdown function, which of course was academic as the relay was already latched up since an engine sequence had not been initiated.

3.6.2 Command System

Measurements: H6 Clock Temperature (177.8° F steady)
 H7 Memory Temperature (64.4° F steady)
 H33 Programmer Power Supply Temperature (73.3° F steady)
 H27 Programmer B + No. 3 [60.94 vdc^(a) 59.62 vdc^(b)]
 H28 Programmer B + No. 2 [40.96 vdc^(a) 40.06 vdc^(b)]
 H29 Programmer B + No. 1 (5.87 vdc steady)
 H30 Programmer B + No. 4 (-5.61 vdc steady)

(a) Before liftoff

(b) After liftoff (normal for clock start)

There were no problems with the command system. The vehicle clock started at liftoff (+0.426 sec) and was counting properly throughout the flight to LOS.

The UHF signal strength was adequate after separation and throughout the flight until phase lock was lost at 413 sec. This corresponds to the range safety receiver signal strength (same frequency from the same transmitter) which dropped below threshold at about the same time.

The only action required of the command system was a stored program command at 250 sec to commence recording data. This event occurred on schedule.

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3.6.3 Telemetry System

Measurements: H180 PCM Tray Temperature (62° F steady)

H62 VHF Transmitter No. 1 Temperature (81.5° F until 435 sec)

H63 VHF Transmitter No. 2 Temperature (65.9° F nominal)

Telemetry system performance was satisfactory throughout the flight. AFETR data shows a number of sync losses which are attributed to marginal ETR acquisition. GBI data had only one major sync loss, at 130 sec, throughout the time from +40 sec to LOS. Adequate telemetry coverage was provided, therefore, for the entire flight. All telemetry temperatures were normal. Transmitter No. 1 was on and its temperature rose from 81.5° to 89.1° F during the course of the flight. Transmitter No. 2 was off and the temperature remained at a nominal 65.9° F.

3.6.4 Tracking System

Measurements: H47 S-band Input PRF

H48 S-band Output PRF

H49 S-band Transponder Temperature (75° to 78° F)

H177 C-band Transponder Temperature (74° to 82° F)

H174 C-band Output PRF

Both the C- and S-band transponders operated correctly throughout the flight except during the blackout period of 12 sec and were being interrogated and responding at LOS. Temperatures were nominal during flight.

3.6.5 Instrumentation

The instrumentation system operation was satisfactory and adequate data coverage was provided for the mission. A total of 236 analog and/or step function parameters were measured. No failures or loss of data points were experienced.

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One anomaly did occur, that of measurement A522, accelerometer Y No. 2 (aft). At Atlas/GATV separation, this measurement shifted approximately 0.75 g in a positive direction and remained at this position for the rest of the flight. The measurement continued to give vibration and acceleration data.

There were no other instrumentation anomalies and 100 percent of the instrumentation was active at LOS.

3.7 RELIABILITY

GATV 5004 did not achieve orbit because the booster exit thrust attitude was uncontrolled. From a success or failure standpoint, the flight is considered a "no-trial" for the Agena.

3.7.1 Agena Flight Data

Flight data indicate the following Agena equipment anomalies during the severe attitude excursions preceding Atlas/GATV separation:

- Phase CB output of the 3-phase inverter dropped to 0 v, and phase AB dropped below the specification minimum of 113.85 v.
- The ascent sequence timer did not start.

3.7.2 Analysis

Type XII-A Inverter

Based on ground test records, the GATV 5004 inverter was an acceptable unit. Histories of all previously flown inverters were reviewed, and no troubles, similar to the GATV 5004 inverter problem, were found. During special bench testing it was demonstrated that an excessive load across the inverter output would produce symptoms which occurred in the flight unit. The sequence timer and inertial reference package (IRP) both are powered by the inverter. The possibility of the sequence timer and IRP causing excessive load on the inverter was investigated.

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Ascent Sequence Timer

Manufacturing data, for the GATV 5004 sequence timer, was reviewed. The failure history of all sequence timers was also studied. There is no record of a seized motor which could cause excessive load on the inverter.

Inertial Reference Package

Test and failure data for the IRP SMRDD transformers were analyzed. No record of a shorted transformer was found. A non-destructive test in which a short was placed on the IRP gyro motor transformer secondary windings displayed voltages similar to GATV 5004 flight conditions. However, the current levels were lower than those observed during the flight anomaly.

3.8 AEROSPACE GROUND EQUIPMENT

Aerospace ground equipment (AGE) performance in support of checkout and launch of GATV 5004 was satisfactory.

3.8.1 Countdown

A hold in the countdown of approximately 15 min was incurred during IRFNA loading. The additional time required to load IRFNA was due to clogging of the fill-line filter. Although the IRFNA was within specifications, the fill-line filter collected a sufficient quantity of contaminants during the pre-countdown propellant conditioning phase and the vehicle loading phase to lower the IRFNA flow rate and lengthen the fill time required. To prevent recurrence of this problem, both the fill-line filter and the circulation filter will be cleaned and replaced prior to countdown in future operations.

3.8.2 Pad Damage

Pad damage was light. The only damage of note occurred in the P100 electrical umbilical plug. This plug will be replaced prior to launch of GATV 5005.

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Section 4

CONCLUSIONS AND RECOMMENDATIONS

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Section 4
CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

GATV 5004 performed as designed while being subjected to the severe environment caused by the Atlas anomaly.

All equipments (except the 3-phase power system) and instrumentation operating prior to BECO continued to operate until the vehicle reentered the atmosphere and a complete loss-of-signal was experienced (456.6 sec).

The only malfunction was the apparent overloading of the Type XII-A Inverter and loss of phase BC voltage. The loss of 3-phase power prevented the operation of the D-Timer with the result that no programmed Agena events occurred. The most probable cause of the overload on the inverter was arcing at the J-100 umbilical as the Atlas/GATV was flying backwards through the ionized exhaust gases of the Atlas engines.

The accelerometers functioned as expected during the flight. Steady-state accelerations were quite readable and provided valuable information for flight analysis. However, to interpret vibration data from these instruments is misleading and of questionable value for diagnostic purposes.

Valid data were received from the 14 skin temperature sensors from liftoff until loss-of-signal. Data appears to indicate an essentially nominal flight up to 120 sec. After 120 sec there are indications of significant negative pitch angles-of-attack. With the exception of the 400-cps inverter in the forward rack, all equipment and structural temperature histories were normal up to approximately 400 sec after liftoff.

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GATV 5004 separated from the Atlas in a normal manner upon backup command from the Atlas.

Because of the slight delay experienced in loading Agena oxidizer prior to liftoff, AFETR procedures have been modified to include changing all filters in the AGE facility propellant systems prior to vehicle loading to preclude excessive pressure drop in facility lines.

The Agena was subjected to a severe flight test as a result of the Atlas anomaly; thorough review of the data did not indicate any inherent weakness in the Agena.

4.2 RECOMMENDATIONS

Based on the results of this systems test evaluation, no changes to the Agena or any of its subsystems are recommended.

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